BELLCOMM, INC.

SUBJECT: Trip Report - Sixth AAP-4 Unmanned Rendezvous Meeting at MSC, June 27, 1968 - Case 610

DATE: July 5, 1968

FROM: C. O. Guffee

ABSTRACT

Highlights of the presentations and discussions are:

1. Grumman recommends that the mission be planned with two shipsets of propellant, and that the rendezvous profile be the hybrid stable orbit profile,

2. Automatic station keeping is expected to require a Δv capability of about 15 fps per orbit,

3. All contractors recommend non-orthogonal indexing of the CM to the OWS,

4. Grumman and North American Rockwell recommend that the command link between the CM and LM/ATM use PSK coding scheme.

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MEMORANDUM FOR FILE

Introduction

Presentations were given by Grumman, McDonnell Douglas, North American Rockwell, and MIT. Important conclusions of the contractors and study directions of MSC are summarized below. A complete set of the presentations is available through the author.

Rendezvous Profile/Propellant Requirements

Grumman recommends that the AAP-4 mission be planned with two shipsets of propellant. This is based upon simulation studies which indicate that the minimum propellant requirement for the hybrid stable orbit profile with 3σ errors exceeds one shipset. The figures are as follows:

Nominal Propellant Requirements	242.3 lbs.
Additional Requirements due to 3σ Errors	252.4 lbs.
Total Requirements (for 3σ errors)	494.7 lbs.
Minimum Available Propellant (one shipset)	490 lbs.

This includes requirements from separation through docking, but does not include propellant required for station keeping.

Grumman then recommended that the AAP-4 rendezvous profile be the hybrid stable orbit profile with the LM/ATM inserted 50 nm ahead of the OWS. Rendezvous would then consist of a 360 degree transfer to a point 10 nm ahead of the OWS followed by a 240 degree terminal phase transfer. The propellant requirements for this profile are as follows:

Nominal Propellant Requirements	270.5 lbs.
Additional Requirements due to 3σ Errors	251.2 lbs.
Total Requirements (for 3σ errors)	521.7 lbs.
Minimum Available Propellant (two shipments)	977.2 lbs.

These requirements do not include station keeping, but 455.5 lbs of propellant are available for this function.

Automatic Station Keeping

Accuracy of the rendezvous radar for the range required during automatic station keeping of the LM/ATM still is uncertain. MSC directed MIT to examine the radar specifications and to determine if an error model for ranges in the order of 1000 feet now exists. If models do not exist then MIT is to specify what information is required in order to develop a model. MIT is to also make recommendations as to what types of filtering and estimation models should be used with the radar data during station keeping. The use of radar data at the closer ranges required for automatic station keeping is expected to be different from the present Apollo program.

Grumman studies have confirmed the McDonnell Douglas study concerning propellant requirements for automatic station keeping as a function of relative velocity uncertainty. For velocity uncertainty less than 1.0 fps, less propellant is required to station keep behind the OWS; however, for uncertainty greater than 1.0 fps less propellant is required to station keep above the OWS. For velocity uncertainty of approximately 1.0 fps, the required Δv per orbit is about 15 fps for automatic station keeping either above or behind the OWS.

CM/OWS Indexing - RR Transponder Location

Grumman, North American Rockwell and McDonnell Douglas all made recommendations concerning CM indexing for docking to the OWS and rendezvous radar transponder coverage. All recommended non-orthogonal indexing of the CM to the OWS regardless of whether the transponder is as it now exists, is relocated or spherical coverage provided. Each contractor gave the advantages and disadvantages of their recommendation. North American also discussed the addition of a second transponder antenna to the CM/SM, with a select switch to activate the desired transponder antenna.

LM/ATM Manual Remote Rendezvous

MSC directed North American Rockwell to investigate remote control of the LM/ATM rendezvous for the case of rendezvous radar failure. North American is to assume that MSFN controls the LM through TPI and is able to transmit the LM state vector to the CM after TPI. The CM crew would use the remote command link and would have only SXT and UHF ranging measurements, but would not be able to navigate the LM state vector through any of the succeeding burns. North American is to investigate both Lambert guidance and guidance controlling LOS rate and range rate.

CM/OWS Rendezvous

MSC directed North American to begin investigating CM-SM rendezvous with the OWS. MSC also asked MIT to investigate IMU gimbal lock problems which might exist if the CM is docked to the OWS from normal to the orbital plane. MSC would prefer not realigning the IMU for docking. Capability for slewing of the inner gimbal is presently being implemented into the Apollo program, and MSC wants to know if this capability would aid in the AAP-3 rendezvous and docking problem.

Remote Control Communication Link

Grumman tests indicate that PSK data transmission via clipped VHF AM has a high bit error rate and is unacceptable. The problem is that knowledge of zero crossings cannot be maintained in the receiving equipment.

Both Grumman and North American recommend that the command link use a PSK coding scheme as is presently used in Apollo LM for the S-band uplink commands. MSC directed both contractors to investigate synchronous vs asynchronous signal transmission.

LM/ATM Remote Controlled Docking

McDonnell Douglas is establishing an analogue, man-in-the-loop simulator for investigating docking of the LM/ATM to the OWS. It is anticipated that the simulator will be complete within two weeks.

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